Chapter 8

Environmental Aspects of Mining and Rehabilitation

Environmental aspects of mining and rehabilitation

1. INTRODUCTION

Cement manufacturing process has various impacts on the environment and the ecology. For this reason, most countries impose strict legislation for environmental protection. It is therefore essential to consult the environmental regulations when selecting potential raw materials resources. Rehabilitation planning can be carried out with the help of the special "Holderbank" software, Quarry Engineering Design (QED). A clear presentation of the different phases of minerals exploitation and quarry rehabilitation with 3D animation can be shown.

2. ECOLOGY

Ecology is defined as the relationship between nature (plants, animals), man and the environment. The environment is the sum of all external forces or influences. Every plant and animal exists within a unique and continually changing microenvironment. The ecosystem is made up of three of ecological systems:

- individual
- population
- ecosystem

The ecosystem, being a balance or equilibrium of the existence and the interactions between populations, has been disrupted by man causing a profound change of these balanced ecosystems.

In part, the quarrying activities can be disruptive, if not totally destructive to an ecosystem. Apart from the more apparent effects of an anaesthetic pollution caused by dust and smoke, there is also the local destruction of the flora and fauna. Usually, quarries are situated in rocky outcrop areas, where the overburden is very thin. These areas are often the refuge of various animals and specific plants.

What can be done do to minimise, divert or correct such disruptive effects of quarrying activities?

3. REHABILITATION OF QUARRIES

Rehabilitation schemes as part of an exploration concept include the reincorporating of the quarry area into the surrounding landscape, its re-cultivation with the purpose of creating an integral ecosystem with a new function. The possibilities of utilising a worked-out quarry are numerous. Apart from the most common utilisation in agriculture and forestry, it could also serve for industrial purposes such as a site for a power plant or a refuse tipping site.

Possibilities of utilisation of a work-out quarry are as follows:

- Agriculture
- Forestry
- Recreation areas: woods, ponds, rock garden
- Scientific activities
- Sanctuary (wild life)
- Pisciculture
- Lakes, ponds
- Sporting grounds
- Tipping areas
- Commercial/ industrial : storage area, traffic area, training area...

Experience has shown that a decision on the future utilisation of an exhausted quarry should be made very early on in the project program. Terms of an agreement between the exploiting company and the executive of public planning authorities must be drawn up and implemented.

In each individual case, local conditions will determine the choice of the rehabilitation programme and accordingly the cost estimates including return of investment. In the example described in table 1 which is an average case, the cost for rehabilitation is approximatly $ 100'000 per ha or $10 per m^2.

Table 1: Cost for quarry rehabilitation

Activities	**Cost in $/m^2**
Soil removal	1.00
Preparation of filling materials	1.00
0.3 m soil cover	2.00
0.35 m humus cover	2.00
Plants	1.00 -2.00
Wood	2.00
Spraying of slopes	1.00 - 2.00
Forestation	1.00

A rehabilitation or utilisation scheme is established after a thorough evaluation the most important factors, namely geological conditions and the groundwater situation. In a second stage, data on weather conditions, landscape planning, economy, need to be collected and evaluated.

4. EXAMPLE OF REHABILITATION

There are many examples of recultivation / rehabilitation of quarries in many countries. One such example is the problems caused as a result of uncontrolled landfill in Switzerland.

4.1 Landfill of the quarry "Bärengraben", Switzerland

This state owned limestone quarry was exploited between 1930 and 1960 as raw materials source for a cement plant. A thick overburden consisting of sand and conglomerate overlies the suitable limestone resource. Exploitation of the limestone occurred on the flank of the hill, leaving an exposed open-cut slope.

1960 to 1975. Once exploitation of limestone had ceased in 1960, the quarry was utilised as a repository for demolition material and organic wastes. In 1975, as the quantity of waste materials increased considerably, the local authorities decided it was necessary to establish a waste management system.

In 1975, the situation was as follows :

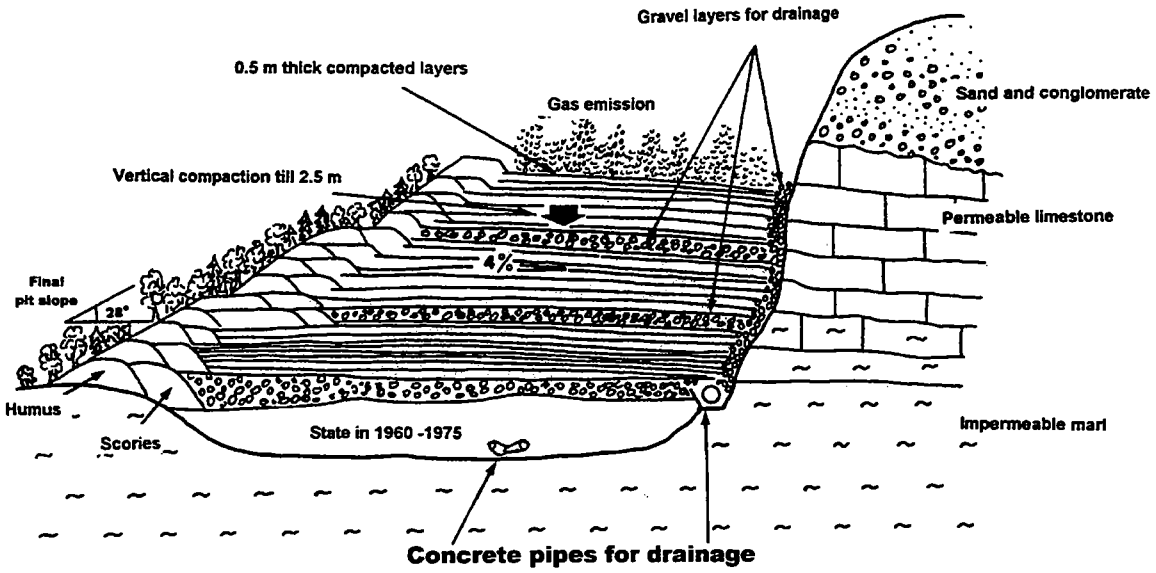
- deposition of materials of demolition materials (inert building rubble) was mixed with other waste material. Uncontrolled waste waste deposition.
- drainage system (cement pipes to collect the groundwater) was defective due to aggressive water (high content in sulphate)

From 1975 onwards, the new project of landfill consisted of (Fig 1):

- a new drainage system with gravel beds between waste layers and along the slopes of the quarry
- establishment of the final slope of the deposition materials in order to avoid slope failure (landslides)
- installation of a measurement system to determine compaction
- cladding the external slope with soil and humus
- a compactor

The price of the installation and the costs of the operation amounted to CHF110.- per cubic meter of waste.

Fig. 1 Cross-section of the landfill / quarry at Bärengraben



Compacting was regular and there were no problems with the drainage installation.

For many years, this quarry was backfilled without any control of the quality of the materials being dumped. With the result that the waste materials consisted of building rubble and other disallowed products. For example :

- domestic waste and detritus
- scories of two chemical plants
- excavation materials contaminated by acetate and acids
- inert materials of demolition

However, in 1986 at the end of the landfill, groundwater investigations in the valley confirmed that as a result of the migration of contaminated water out of Bärengraben the groundwater in the main valley was contaminated. Hazardous wastes are lixiviated by the clean groundwater flowing thorough the overburden and limestone. This drainage water, or deposition juice, flows into a small basin of decantation on the site before permeating back into the groundwater system. This contaminated water contains heavy metals, which are very dangerous to the health.

The groundwater is the potable water source for many villages in the area. Fig. 2 shows the situation of the groundwater circulation. It was estimated that 45 l/minute of contaminated water, which is not successfully collected in the drainage pipes, flowed into the valley.

A project to collect all the contaminated water was implemented. This involved construction of a collection tunnel behind as well as an impermeable barrier in front of the repositry, in order to prevent contaminated water flowing into the groundwater. The cost estimation amounted to CHF40 - 60 Mio.

Early in 1990, signifcant gas emissions coming from the decomposition of organic materials incommoded the people of the village near the old quarry. In order to collect this gas a system of boreholes and pipes was installed. This consisted of a flow system for the gas equipped with a ventilator, an analyser (continuous analysis of the gas) and a gas burner. The quality of gas was not sufficiently good enough for commercial use (low methane).

Fig. 2 Hydrogeological model of the landfill of Bärengraben